PATENT SPECIFICATION

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COMPLETE SPECIFICATION

Supercharging of Internal Combustion Engines

We, D. NAPIER & SON LIMITED, a Company registered under the Laws of Great Britain, of 211, Acton Vale, London, W.3, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to supercharging of an internal combustion engine provided with a turbo-blower that is to say an air compressor arranged to supply supercharging (and probably also scavenging) air to the engine and coupled to a turbine driven by the exhaust gases of the engine.

The invention is concerned particularly with the difficulties that occur when such an engine is receiving insufficient air from the turbo-blower. One cause of such a drop in air delivery is malfunctioning of one or more cylinders, or of one complete bank of an engine, or even of a whole engine where two or more engines are coupled together. Any such failure will affect the exhaust gases and reduce the power available at the turbine. Another possible cause is a failure in the turbo-blower itself, either in the turbine or the compressor. Moreover if the engine is to run continuously for long periods at low power and speed, it is possible that the air supplied by the turbo-blower may be insufficient to meet requirements.

Various prior proposals have been made to meet these conditions. One proposal provided an auxiliary source of power which could be coupled to the turbo-blower. Another proposal involved the use of an auxiliary compressor arranged in parallel with the air delivery passage through the turbo-blower. These previous proposals however have proved unsatisfactory for one reason or another, and it is an object of the invention to provide an improved supercharging system which will be simple to install and effective in operation.

A supercharging system according to the invention comprises a turbo-blower arranged to deliver compressed air to the air intake of the engine and an auxiliady compressor driven independently of the engine and of the turbo-blower, and an air ducting system including a duct between the auxiliary compressor and the turbo-blower whereby the air flow passage of the auxiliary compressor can be connected in series with the air flow passage of the turbo-blower and upstream thereof, and including duct means for connecting the air intake of the turbo-blower directly to atmosphere, during normal operation of the turbo-blower, the duct means including a non-return valve permitting air to flow towards the air intake of the turbo-blower but preventing air flow in the opposite direction.

One of the main advantages of this system is that the auxiliary compressor does not have to be exactly matched to the characteristics of the turbo-blower, since it does not necessarily deliver directly into the engine air intake manifold. Moreover when the turbo-blower is operating normally, and effectively, the auxiliary compressor can readily be disconnected.

During normal running therefore only a small percentage if any of the supercharging air is required to pass through the stationary auxiliary compressor, which would lead to pressure losses.

The invention is particularly applicable to systems including two turbo-blowers arranged in parallel, in which case a single auxiliary compressor may be provided in series with the two turbo-blowers. Means would normally be provided in this system for selectively closing the air ducts between the auxiliary compressor and the two turbo-blowers.

In any case the auxiliary compressor is preferably driven by a multi-speed electric motor. Another alternative drive would be a steam turbine.

The invention may be performed in various ways but one specific embodiment will now be described by way of example as applied to a two-stroke 6-cylinder compression ignition

engine illustrated diagrammatically in the accompanying drawing.

The engine illustrated diagrammatically at 1 has an air intake manifold divided into two parts 2, 3, by a connection 5 of the bolted flange type, including a removable apertured plate 6, which may be replaced when desired by a blank plate, which thus divides the manifold. Two air compressors 7, 2, which are driven respectively by exhaust turbines 9, 10, are connected via coolers 18 to the respective parts of the manifold. The exhaust gases to drive each turbine are led through ducts 11 from the three cylinders of the engine to which air is normally supplied through the corresponding part of the intake manifold.

The air intake to each compressor 7, 8, includes a valve chamber 12, 13, and an air filter 14, 15. The valve chambers contain automatic non-return valves 16, 17 (shown in their open positions) which allow air to enter through the filters but close automatically if the pressure rises appreciably in the valve chambers, and thus prevent air escaping in the reverse direction through the filters.

A single auxiliary compressor or fan 20 is provided, the delivery passage 21 of which is connected to a branched duct 22 leading to the valve chambers 12, 13, in the air intakes of the main compressors 7, 8.

The connections between the ends of the branch duct 22 and the valve chambers 12, 13 are by means of flanges on these parts, which are bolted together. These flanged connections each include an intermediate removable ring 23, 24 which may be substituted by a blank plate when desired to close the connection.

The delivery passage 21 from the auxiliary compressor also communicates with a branch duct 25, the opposite ends of which are connected to the two parts 2 and 3 of the inlet manifold by bolted flange connections including removable flange rings 26, 27 corresponding to the flange rings 23, 24. Thus by substituting blank plates for the rings 26, 27, these two connections may similarly be closed when required.

The auxiliary fan 20 is driven by a two-speed electric motor 28, the lower speed being used during continuous low power running of the engine. Blow-off valves might be provided to reduce the delivery pressure of the auxiliary fan in these conditions, but this will probably not be necessary, particularly since the electric motor is a variable speed type.

During normal running operation the auxiliary motor 28 is switched off and with the turbo-blowers 7, 9, 8, 10 running normally air flows inwards through the filters 14, 15, the non-return valves 16, 17 being open, and is delivered from the main compressors 7, 8, to the manifold 2, 3. During such normal operation the flange rings 26, 27 are replaced by blank flanges. A small proportion of the air drawn in by the compressors 7, 8 will thus be drawn through the ducts 22 and 21 and through the auxiliary fan 20 causing this fan to rotate at a low speed which is of advantage in preventing the bearings of this fan from deteriorating as might occur if it were stationary for long periods.

For prolonged low power operation, for example for manoeuvering purposes in a marine propulsion unit, the motor 28 is run at low speed and air is supplied through ducts 21 and 22 to the valve chambers 12, 13. The turbo-blowers 7, 9, 8, 10 are operating below full efficiency and the air supplied from the auxiliary fan 20 closes the non-return valves 16, 17 and this air is passed through the compressors 7, 8 to the engine manifold. If the engine speed increases the suction from the compressors 7, 8 will open the non-return valves 16, 17 to admit extra air through the filters 14, 15 until at a predetermined speed of the engine the motor 28 driving the auxiliary fan can be switched off.

If one turbo-blower should fail either in the turbine or compressor, for example the left hand unit 8, 10 in the drawing, the rotor of this unit is locked positively and a blank flange plate is inserted at 23 in the connection between the duct 22 and the serviceable turbo-blower 7, 9. The blank flange at 27 between the duct 25 and the manifold section 3 is removed, the opposite blank flange 26 being retained. The motor 28 is then run at top speed driving the auxiliary fan 20 and supplying air directly through the duct 25 into the manifold section 3 which has previously been fed by the now inoperative turbo-blower 8, 10. A proportion of the air from the auxiliary fan will also pass through the duct 22 into the intake of this inoperative compressor 8 and thence into the manifold section 3, but none of the air from the auxiliary fan will pass to the compressor 7. The air which is passed in this way through the inoperative compressor 8 thus cools this compressor so that it is unnecessary to divert the hot exhaust gases from the exhaust duct 11, which can continue to pass through the turbine 10. This air supply will also be used in the normal way to fill the conventional air seal on the shaft between the compressor 8 and the turbine 10 which will also prevent the hot exhaust gases reaching the compressor along the shaft.

Under these conditions, with one turbo-blower inoperative, the operative turbo-blower and the auxiliary fan thus work largely in parallel supplying air to the two manifold sections 2, 3. It may be of advantage to replace the apertured plate 6 between these two manifold sections by a blank plate thus separating the two manifold sections completely.

If both turbo-blowers should fail it is only necessary to remove the two blank flanges at 26 and 27, and lock the turbo-blowers. The motor 28 is then run at top speed and the auxiliary fan delivers air directly into the two

manifold sections 2, 3, a small proportion of this air passing through the branch duct 22 to cool the two compressors 7, 8 in the same way as described above. The system will operate even if the flange plates 26, 27 are not removed, in which case the whole of the air from the auxiliary fan will pass through the inoperative compressors 7, 8. There will however be some reduction in the pressure in the air manifold sections 2, 3 since all the air will then be passing through the stationary main compressors.

It will be appreciated that the flange connections 23, 24, 26, 27, 5 and 6 may if required be replaced by simple valves. In any case it will be noted that these connections are all cold and can therefore be handled immediately a failure occurs without having to allow them first to cool.

It will be appreciated that since the air flow through the turbo-blowers is in the same direction irrespective of whether the auxiliary fan is operating or not, the turbo-blowers will not have to overcome any back pressure when they start up. This is a distinct advantage over a parallel flow arrangement of turbo-blower and auxiliary fan, where the turbo-blower may have to pass through the surge point when it starts up and the speed of the auxiliary fan would probably have to be controlled manually.

It will also be understood that if required a pair of auxiliary compressors may be provided, one in series with, and upstream of each of the turbo-blowers. Again each auxiliary compressor will be driven by a two-speed electric motor. In this case no shut-off valves need be provided in the duct between each auxiliary compressor and the associated turbo-blower, though automatic non-return valves are provided in branch ducts at the turbo-blower air intakes, to enable air to enter freely without passing through the auxiliary compressors.

WHAT WE CLAIM IS:—

1. A supercharging system for an internal combustion engine comprising a turbo-blower arranged to deliver compressed air to the air intake of the engine, and an auxiliary compressor driven independently of the engine and of the turbo-blower, and an air ducting system including a duct between the auxiliary compressor and the turbo-blower whereby the air flow passage of the auxiliary compressor can be connected in series with the air flow passage of the turbo-blower and upstream thereof, and including duct means for connecting the air intake of the turbo-blower directly to atmosphere, during normal operation of the turbo-blower, the duct means including a non-return valve permitting air to flow towards the air intake of the turbo-blower but preventing air flow in the opposite direction.

2. A supercharging system as claimed in Claim 1 including a second turbo-blower arranged in parallel with the said turbo-blower to deliver compressed air to the air intake of the engine, the auxiliary compressor and the air ducting system being arranged to connect the auxiliary compressor in series with and upstream of the two turbo-blowers, and including duct means for connecting the air intakes of each of the two turbo-blowers directly to atmosphere, each of the duct means being provided with non-return valves permitting air to flow towards the intake of the respective turbo-blower.

3. A supercharging system as claimed in Claim 2 including closure means in each of the air passages between the auxiliary compressor and the turbo-blowers.

4. A supercharging system as claimed in any of the preceding claims including a bypass air ducting system whereby the air flow passage of the auxiliary compressor can be connected directly to the air intake of the engine, and closure means in said by-pass ducting system.

5. A supercharging system as claimed in Claim 4 in which the air ducting system is capable of connecting the auxiliary compressor simultaneously to the air intake of the engine and to the air intake of the turbo-blower or turbo-blowers.

6. A supercharging system as claimed in any of the preceding claims in which the auxiliary compressor is driven by a multi-speed electric motor.

7. A supercharging system for an internal combustion engine substantially as described with reference to the accompanying drawing.

KILBURN & STRODE,
Agents for the Applicants.

PROVISIONAL SPECIFICATION

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This invention relates to supercharging of an internal combustion engine provided with a turbo-blower, that is to say an air compressor arranged to supply supercharging (and probably also scavenging) air to the engine and coupled to a turbine driven by the exhaust gases of the engine.

The invention is concerned particularly with the difficulties that occur when such an engine is receiving insufficient air from the turbo-blower. One cause of such a drop in air delivery is malfunctioning of one or more cylinders, or of one complete bank of an engine, or even of a whole engine where two or more engines are coupled together. Any

such failure will affect the exhaust gases and reduce the power available at the turbine. Another possible cause is a failure in the turbo-blower itself, either in the turbine or the blower. Moreover if the engine is to run continuously for long periods at low power and speed, it is likely that the air supplied by the turbo-blower will be insufficient to meet requirements.

Various prior proposals have been made to meet these conditions. One proposal provided an auxiliary source of power which could be coupled to the turbo-blower. Another proposal involved the use of an auxiliary blower arrangein parallel with the air delivery passage through the turbo-blower. These previous proposals however have proved unsatisfactory for one reason or another, and it is an object of the invention to provide an improved supercharging system which will be simple to install and effective in operation.

A supercharging system according to the invention comprises a turbo-blower arranged to deliver compressed air to the air intake of the engine and an auxiliary blower driven independently of the engine and of the turbo-blower, and an air ducting system whereby the air flow passage of the auxiliary blower can be connected in series with the air flow passage of the turbo-blower, and upstream thereof.

One of the main advantages of this system is that the auxiliary blower does not have to be exactly matched to the characteristics of the turbo-blower, since it does not deliver directly into the engine air intake manifold. Moreover when the turbo-blower is operating normally, and effectively, the auxiliary blower can readily be disconnected.

Thus according to a preferred feature of the invention the system includes means for connecting the air intake of the turbo-blower independently to the atmosphere, during normal operation of the turbo-blower.

During normal running therefore only a small percentage if any of the supercharging air is required to pass through the stationary auxiliary blower, which would lead to pressure losses.

Preferably the air intake of the turbo-blower is connected to atmosphere through a non-return valve, arranged to close automatically when the air intake pressure rises appreciably above atmospheric, that is to say, when the delivery pressure from the auxiliary blower exceeds the suction pressure of the turbo-blower.

The invention is particularly applicable to systems including two turbo-blowers arranged in parallel, in which case a single auxiliary blower may be provided in series with the two turbo-blowers. Means would normally be provided in this system for selectively closing the air ducts between the auxiliary blower and the two turbo-blowers.

Alternatively an auxiliary blower might be arranged in series with and upstream of each of the two turbo-blowers.

In any case the auxiliary blower is preferably driven by a variable speed, or two speed, electric motor.

The invention may be performed in various ways but two specific embodiments will now be described by way of example as applied to a two-stroke 6-cylinder compression ignition engine.

The engine air intake manifold is divided into two parts, with an intercommunicating duct, and each part of this manifold is connected to the delivery side of the air compressor of a turbo-blower, the turbine of which is driven by the exhaust gases of the three cylinders to which air is supplied through the respective part of the manifold.

In the first example a single auxiliary blower is provided, the delivery side of which is connected to a branched duct which communicates with the air intake sides of the two turbo-blowers. The two arms of this branched duct contain shut-off valves. The intake sides of the two turbo-blowers, on the downstream side of the shut-off valves, are also connected to atmosphere through automatic non-return valves, which allow air to enter, but prevent it being discharged at these points.

The auxiliary blower is driven by a two-speed shunt wound electric motor, the lower speed being used during continuous low power running of the engine. Blow-off valves might be provided to reduce the delivery pressure of the auxiliary blower in these conditions, but this will probably not be necessary, particularly since the electric motor is a variable speed type.

It will be appreciated that since the air flow through the turbo-blower is in the same direction irrespective of whether the auxiliary blower is operating or not, the turbo-blowers will not have to overcome any back pressure when they start up. This is a distinct advantage over a parallel flow arrangement of turbo-blower and auxiliary blower, where the turbo-blower may have to pass through the surge point when it starts up and the speed of the auxiliary blower would probably have to be controlled manually.

In the second example a pair of auxiliary blowers are provided, one in series with, and upstream of each of the turbo-blowers. Again each auxiliary blower is driven by a two-speed electric motor. In this case no shut-off valve is provided in the duct between the auxiliary blower and the turbo-blower, though automatic non-return valves are provided in branch ducts at the turbo-blower air intakes, to enable air to enter freely without passing through the auxiliary blowers.

In both examples by-pass ducts including shut-off valves may be provided for each turbo-blower. Thus the air flow from the auxiliary

blower can be led to the air intake manifold of the engine without passing through the turbo-blower. This provision may be useful in the event of shut-down of one of the turbo-blowers.

In a typical example relating to a six cylinder engine fitted with two turbo-blowers the engine particulars at full power were:

B.H.P. 8000
R.P.M. 112
B.M.E.P. 87.5 lbs./sq. in.
M.I.P. 100 lbs./sq.in.

To take a bad case where one turbo-blower fails altogether the requirements would be approximately as follows:

Air delivery of auxiliary blower: 7.75 lbs./sec.

Engine manifold pressure to be sustained: 1.251 lbs./sq. in.

Minimum horse-power of auxiliary blower: 47.

KILBURN & STRODE,
Agents for the Applicants.

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815,387 COMPLETE SPECIFICATION
1 SHEET

This drawing is a reproduction of the Original on a reduced scale.